5 THE ATMOSPHERIC CHEMISTRY PROGRAM

5.1 OVERVIEW

Richard J. Larsen

The Department of Energy's Atmospheric Chemistry Program (DOE/ACP) was initiated in 1991 to coordinate the atmospheric chemistry research between universities and federal laboratories (OHER, 1993). The program's main focus is on the atmospheric source-receptor sequence from energy-generating sources. The primary objective of the program is to provide DOE with information about the atmosphere that is required for long-range energy planning in fulfillment of the National Energy Policy Act of 1992 (OHER, 1995).

During 1995, the Environmental Measurements Laboratory (EML) participated in ACP by conducting research in the five areas listed below:

1. "EML Sample Archives": The objective of this work is to provide a comprehensive computer generated database that incorporates all of the measurements from relevant EML environmental sampling programs. The database will also include a comprehensive listing of samples that were collected in these programs and are currently archived at EML.

2. "Aerosol Characterization on the Gulfstream Aircraft (G-1)": The objective of this study is to provide aerosol characterization in support of the marine aerosol characterization study (MACS). The goal of MACS is to understand the chlorine budget in the marine environment.

3. "^{222}Rn and ^{222}Rn Progeny Measurements on the Gulfstream Aircraft (G-1)": The objectives of this work are to test and evaluate a newly developed instrument designed to measure charged ^{218}Po in the atmosphere; to obtain high quality atmospheric ^{222}Rn measurements using charcoal trap samples; to provide the ACP community with an additional atmospheric tracer; and to use the ^{222}Rn data to validate a newly developed boundary layer model.

4. "Modeling Trans-Pacific Transport of Combustion Products": The objective of this study is to test the reasonableness of the Global Chemistry Model (GchM), which will be used to assess the impact of Asian combustion products on the United States by simulating ^{222}Rn transport from Asia across the Pacific Ocean.

5. "^{222}Rn Source Terms to the Atmosphere": The objective of this work is to provide a global map of ^{222}Rn source terms to the atmosphere. To generate this map, the parameters that affect the spatial and temporal variations of ^{222}Rn exhalation are studied and differences between ^{222}Rn exhalation measurement techniques are identified.

EML's participation in the 1995 Northeast Field Study represented a significant portion of our field effort in ACP. The home base for the field study was Gabreski Airport located on the eastern end of Long Island in New York State. The study was conducted from August 30 - September 9, 1995 using the DOE Research Aircraft Facility's Grumman Gulfstream-1 aircraft (G-1). The G-1, shown in Figure 5.1, is a large aircraft equipped with state-of-the-art instrumentation

for use in atmospheric studies (Spicer et al.,1994). The overall objectives of the field study were to: evaluate the performance of recently developed instrumentation; quantify the chemical and physical development of the boundary layer between New York City and Boston; conduct a pilot study for urban emissions inventory verification within the Boston area and measure trace gas concentrations over the ocean using a trace atmospheric gas analyzer. Dr. Carl Berkowitz, Pacific Northwest National Laboratory, and Dr. Chet Spicer, Battelle Memorial Institute, were responsible for the overall coordination of the scientific missions. During the field study, 12 flights were conducted, each with specific objectives. There were 6 boundary layer, 2 ocean chlorine, 2 emissions inventory and 2 instrument test flights. EML was responsible for aerosol and ^{222}Rn measurements and collections during these flights. We continue to collaborate with Dr. Berkowitz and Dr. Spicer in the interpretive analysis of the data.

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Figure 5.1 The DOE Research Aircraft Facility's Grumman Gulfstream-1 Aircraft (G-1).

5.2 EML SAMPLE ARCHIVES

Robert Leifer and Nita Chan

In recent years there has been a request by the atmospheric modeling community for a complete computer database of all of EML's stratospheric and upper tropospheric radioactivity measurements conducted during the period 1957 through 1983 under the auspices of the U.S. Atomic Energy Commission (AEC), the Energy Research and Development Administration (ERDA) and the Department of Energy (DOE). These data were collected as part of Projects ASHCAN, STARDUST, and AIRSTREAM, collectively known as the High Altitude Sampling Program (HASP), to investigate the impact of the injection of radionuclides and stable compounds into the stratosphere. More than 20,000 filters were obtained during this period and analyzed for up to 20 different radionuclides. In 1995, we completed the first phase of the archive program, which focused on entering all the data from Projects ASHCAN, AIRSTREAM and STARDUST into a radionuclide database (RANDAB) which will be available on-line within the next few months through DOE's Carbon Dioxide Information Analysis Center (CDIAC) at the Oak Ridge National Laboratory. An additional file on stratospheric tritium samples, collected by Dr. Allen Mason of Los Alamos National Laboratory (LANL), during Project AIRSTREAM missions, will be added to RANDAB.

In addition to the radionuclide database, EML's compilation of stratospheric trace gas concentrations has been completed and is available on-line through DOE's CDIAC at:

http://cdiac.esd.ornl.gov

This database, called TRACDAB, contains information on more than 1000 samples, each analyzed for one or more of the following gases: CCl_3F, CCl_2F_2, CCl_4, N_20, SF_6, CO_2, CH_4, CH_3CCl_3, and COS. These data are potentially useful for the development and verification of climate models and understanding stratospheric transport processes. Furthermore, these data may also be useful for modeling the future atmospheric impact of a projected new fleet of stratospheric flying aircraft.

5.3 AEROSOL CHARACTERIZATION ON THE GULFSTREAM AIRCRAFT (G-1)

Robert Leifer, Lambros Kromidas, Brian J. Albert and Richard J. Larsen

To provide aerosol characterization on the G-1 aircraft in support of the marine aerosol characterization study (MACS) on Long Island during August 1995, EML had to design a customized aerosol sampling package. This package contains: (a) a newly designed impactor to characterize the aerosol composition and particle size; (b) a new aircraft aerosol probe; (c) a size distribution instrument; and (d) an integrating nephelometer. A mass flow controller, vacuum system and computer completes the aerosol sampling package. The major objective of the MACS is to understand the chlorine budget in the marine environment. Chlorine is lost from salt particles through reactions with sulfuric or nitric acid. The loss in chlorine has never been fully quantified as a function of aerosol size.

Aerosol Sampling Inlet Design. One of the major concerns when sampling aerosol on a moving platform such as the G-1 is whether the sampled aerosol is representative of the true ambient aerosol. To this end, we have collaborated with Dr. Arnold Muyshondt, University of Arkansas, in the design of a shrouded aerosol probe for the G-1 aircraft (Figure 5.2). To evaluate the performance of this probe, a size distribution instrument located inside the G-1 sampled the aerosol from a manifold that was connected to the inlet of the shrouded probe. A second size distribution instrument mounted directly on the G-1 in the free airstream provided a reference for comparison. The size distribution instrument that sampled from the shrouded probe worked well and provided data with a time and spatial resolution of one minute or 3 km, respectively. The data from the other size distribution instrument will be provided to EML shortly and the performance of the shrouded probe will be determined.

Parallel Impactor (4PI) Study. A new rotating drum impactor, designed at EML, was evaluated on the G-1 during the MACS. This impactor, known as the four-parallel-impactor (4PI), has the capability of collecting four aerosol samples simultaneously. Controlled by a small computer, the impactor can sequentially collect more than 50 samples on a single drum for Scanning Electron Microscopic (SEM) analysis. Two of the drums were selected to have an aerodynamic cut diameter of 0.18 μm and two were chosen to have an aerodynamic cut diameter of 1.0 μm. The sampling time of the impactor can be determined from the counts of the size distribution analyzer for collections at specific times, or the sampling time can be driven by an independent instrument signal such as from a pressure transducer (altitude) or relative humidity sensor, for both in and out of the marine boundary layer sampling. The signal from real time instruments, such as ozone and sulfur dioxide analyzers, can also control the sampling time of the impactor. This impactor uses the same jet design as our single jet impactor. The individual jets of the 4PI are replaceable and allow for the collection of different aerosol sizes. Using our on-board computer, we can adjust the sampling times to collect sufficient giant sea-salt particles for SEM/x-ray analysis.

This impactor weighs about 0.5 kg and is driven by a stepping motor. The aerosols are pulled through a circular jet and impact onto a 5 cm diameter cylinder constructed of aluminum and covered with a coated foil (Apiezone grease or sticky tape). A small d.c. operated vacuum pump maintains a flow of 1.0 L min^{-1} through the impactor. At this flow rate and at STP the impactor has a calculated

50% cut diameter (the size at which 50% of the particles are collected on the stage) of 0.18 μm using the smaller jet. As the altitude increases, the 50% cut diameter shifts to lower sizes. The collection cylinder from this impactor can be removed easily and placed directly in the SEM chamber, either coated or uncoated, for observation and chemical analysis.

An aerosol sampling system was designed, built and tested during this past year. The equipment was mounted in an aircraft rack used on the G-1. Our shrouded aerosol probe was mounted in one of the aircraft windows adjacent to the aerosol sampling rack. The system consisted of a 4PI, six channel optical particle counter (OPC), integrating nephelometer, computer data logger and controller, vacuum pumps and mass flow controllers. The system was fully automated and pre-programmed for aerosol sampling during each flight. A single switch was turned on at the beginning of every flight.

Figure 5.3 illustrates an example of the real-time aerosol observations obtained during the September 4, 1996 marine flight. The aerosol scattering coefficient (σ_{sp}) and aircraft sample altitude are plotted as a function of time. The lowest σ_{sp} (cleanest air) correlates with the highest altitude. Large variations in the σ_{sp} occurred during the flight, reflecting aerosol inhomogeneity, even at constant altitudes.

More than 200 samples were collected for SEM/x-ray analysis from the 4PI. We used the OPC to determine the sampling time for the 4PI. The 4PI, OPC and nephelometer performed well. Data reduction and analysis were started and should be completed during FY 96. Especially important to this research project is the comparison of the ambient OPC measurements with the sampling manifold OPC. These data will tell how well the shrouded aerosol sampling probe performed.

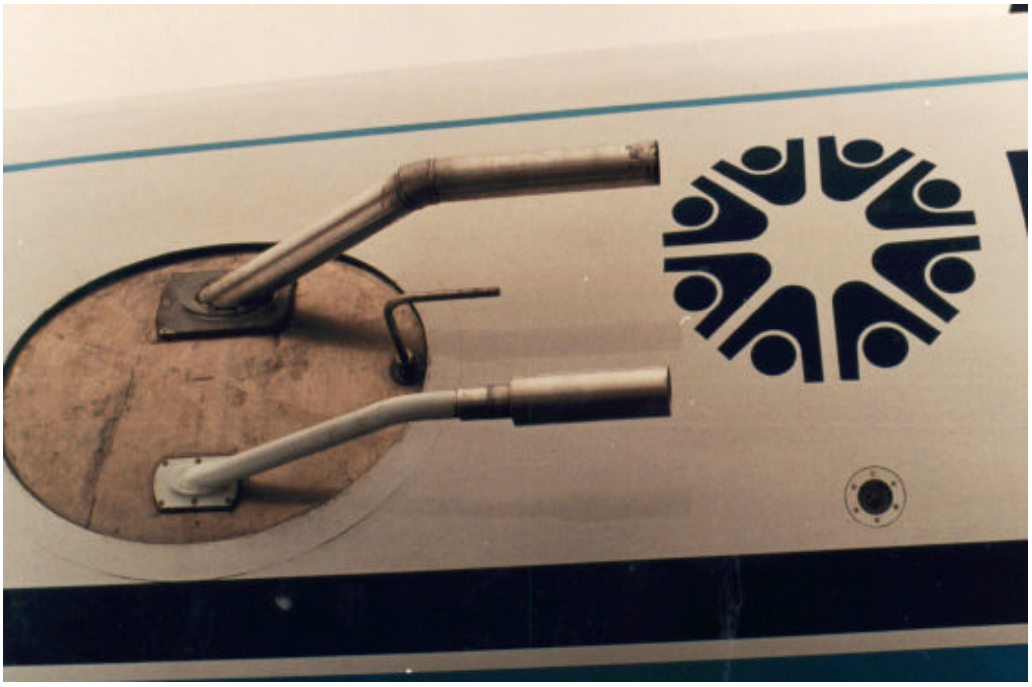

Figure 5.2 View of the G-1 side window containing the radon sampling probe (top probe), the trace atmospheric gas analyzer (TAGA) probe and shrouded aerosol probe (bottom probe).

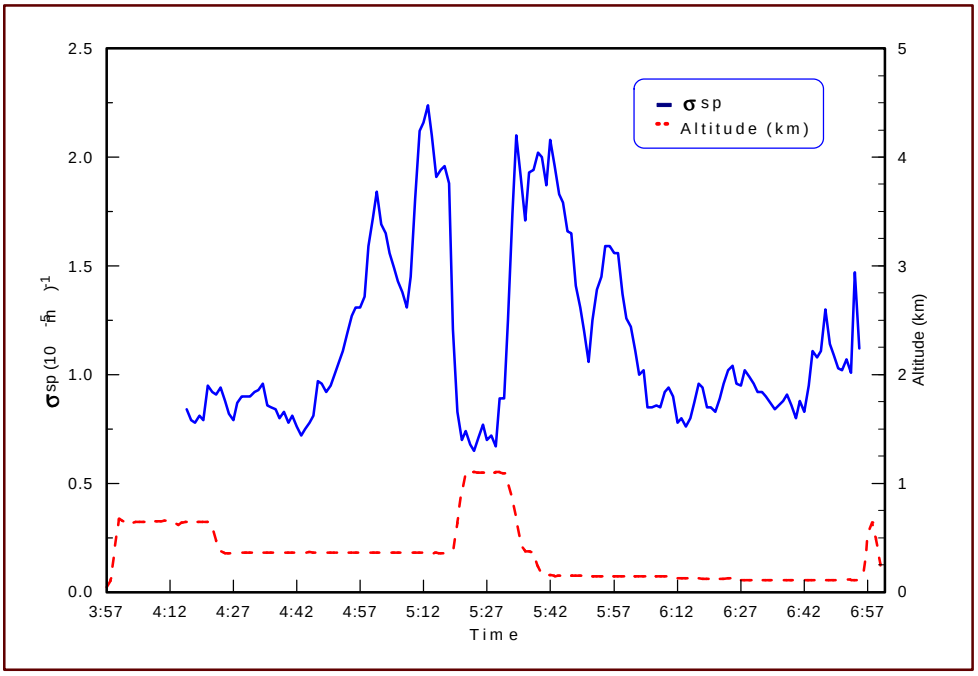

Figure 5.3 A time dependent plot of the aerosol scattering coefficient (σ_{sp}) and G-1 altitude for the September 4, 1995 marine flight.

5.4 ^{222}Rn AND ^{222}Rn PROGENY MEASUREMENTS ON THE GULFSTREAM AIRCRAFT (G-1)

Richard J. Larsen, Brian J. Albert, Harold L. Beck, Norman Y. Chiu, Isabel M. Fisenne, Hsi-Na Lee, Vincent C. Negro, Salvatore C. Scarpitta, William Van Steveninck and Scott B. Wurms

During the 1995 Northeast Field Study, EML successfully used two systems to measure and collect ^{222}Rn in the atmosphere. EML has designed, developed and constructed a new instrument called the "Radgrabber", a compact near real-time radon progeny monitor capable of making precise measurements of charged ^{218}Po from which radon concentrations are inferred. Although not all of the ^{218}Po is charged, the charged fraction in the free troposphere should be relatively high except under conditions of high absolute humidity. Because of the short half-life of ^{218}Po (3.05 min), its concentration should be in close equilibrium with that of its parent, ^{222}Rn, especially in the free troposphere. Because of neutralization processes, it is believed that the effective half-life of charged ^{218}Po is even less than three minutes, making it more representative of the local radon concentration. To evaluate and calibrate the Radgrabber, charcoal trap samples were collected using a newly constructed semi-automated ^{222}Rn gas sampler.

The specific objectives of EML's ^{222}Rn research were to test and evaluate the Radgrabber; to obtain high quality atmospheric ^{222}Rn measurements using charcoal trap samples; to provide the ACP community with an additional atmospheric tracer; and to use the ^{222}Rn data to validate a newly developed boundary layer model.

Radon-222, a radioactive noble gas with a half-life of 3.8 days, is produced from the decay of ^{226}Ra in the earth's crust. The gas diffuses from the soils of the continents into the atmosphere. Since ^{222}Rn is conservative in the atmosphere and is characteristic of air masses that originate over continental areas, it serves as an excellent tracer to indicate and/or verify the presence of continental air, to estimate the transport time of that air from source to receptor and to validate three-dimensional atmospheric transport models. Because the source term of ^{222}Rn is fairly well known, vertical profile measurements of ^{222}Rn over continental regions are used to determine boundary layer parametizations.

The Radgrabber is a unique instrument using concepts never attempted before. The principle of operation is based on the collection of positively charged ^{218}Po atoms directly on the active surface of a solid state alpha detector by using a strong electrostatic field. Alpha spectroscopy is then used to register the electrically charged ^{218}Po. To collect the charged ^{218}Po requires that the entire front-end electronics be referenced to high voltage, which for the ACP flights was 20 kV. Thus, the alpha detector, amplifiers, pulse height analyzer, and the front-end "TattleTale" computer are all referenced to high voltage. These high voltages permit the unit to sample air up to approximately 30 ft^3/minute, which enhances sensitivity. The air flow is provided using aircraft RAM air through a 2" diameter sampling probe. The flow is controlled on exiting the instrument by a mass flow controller. Power for this section is provided by a battery pack which is also referenced to the high voltage and provides about 75 hours of operation. In addition to this high voltage section, there is also a low voltage section consisting of another computer, several sensors, and output signals. The sensors measure

temperature, humidity, both current and voltage from the high voltage supply, and mass flow, while the signals control a display and the electronics in the high voltage section. To control these sections requires special optical techniques to isolate the high voltage. In addition, both computers share data via this optical link. Since two computers are involved, and one controls the other, the software for the Radgrabber was a major effort. However, the end result is a set of very reliable routines that can automatically correct for problems during the flight. If required, the low voltage computer can stop the high voltage computer, clear its programs, and reload new routines from its memory. In operation, the display gives both 3 and 10 minute running averages of the detected ^{218}Po, while for reliability both computers maintain a data file which is read at the end of the flight.

This compact analyzer was designed for use aboard the DOE/ACP G-1 research aircraft, as well as aboard smaller aircraft where space and payload are limited. The instrument is cylindrical in shape with a length of about 1 m and diameter of about 15 cm. The total weight of the instrument, including the sampling probe and mass flow controller, is ~ 36 lbs (probe ~ 6 lbs, instrument ~ 15 lbs; flow controller ~ 15 lbs). The total power required is minimal, 2.5 amps at 28 V.

The prototype instrument was installed and tested aboard the G-1 (Figure 5.4) during the late August-September 1995 flights based out of Long Island. Although the amplifier is compensated for bright sunlight, one effect that was not anticipated was the chopping of the light by the propellers which creates noise pulses. This problem, for which the term “prop-chop” was coined, was resolved by installing a black baffle. Preliminary data indicate that the Radgrabber is reliable and responsive. Further characterization of the Radgrabber is ongoing at Floyd Bennett Field (see Summary No. 5.5).

An automated ^{222}Rn sampler was designed and constructed at EML to collect up to eight ^{222}Rn charcoal trap samples per flight. The sampler was designed to minimize the effort of manually collecting ^{222}Rn charcoal traps during flight by automating the sampling process. The sampler consists of two sections, one holding eight charcoal traps in a dry ice bath, the other containing rotary and solenoid valves, a mass flow controller, a vacuum pump, and a data acquisition computer. During flight, the operator initiates a sample cycle by selecting the next available trap with a manual lever and then pressing a start button. From this point on, the operation is automatic. The solenoid valves, vacuum pump, and mass flow controller are operated in the appropriate sampling sequence and the mass flow is measured during a 10 minute sample collection. The sampler is then reset and is ready for the next sampling cycle. After each flight, the manual valves on each trap are closed and the two sections of the sampler are disconnected, allowing for the removal of the individual traps which are sent back to EML for analysis.

During the 1995 Northeast Field Study, ^{222}Rn was collected on 160 g capacity charcoal absorber traps that were initially designed for aircraft sampling in the stratosphere (Harley and Harley, 1965). After each flight, the sampled traps were delivered to EML for analyses. The ^{222}Rn was desorbed into, and measured in, the EML ^{222}Rn pulse ionization chambers, a primary ^{222}Rn measurements facility described by Fisenne and Keller (1985). The lower limit of detection at the 95% confidence level for the charcoal trap measurements in the pulse ionization chambers was 0.17 pCi or 6.3 mBq. The traps were returned to the field for use on subsequent flights.

To illustrate the performance of the Radgrabber and the semi-automated ^{222}Rn gas sampler,

Figure 5.5 presents the results from the September 3, 1995 flight, a boundary layer mission. Figure 5.5 also depicts the flight path, a box pattern typically used in boundary layer study flights. The circles, numbered sequentially, indicate significant changes in the flight path. Figure 5.6 presents the data obtained during this flight from the Radgrabber and from the analyses of traps collected using the semi-automated ^{222}Rn gas sampler. The figure illustrates the continuous ^{222}Rn record obtained from the Radgrabber and the discrete data obtained from the analyses of the trap samples. As expected, the ^{222}Rn concentration varies inversely with height with a maximum value of 2.3 Bq/m^3 at 348 meters and a minimum concentration of 0.41 Bq/m^3 at 1886 meters. These ^{222}Rn measurements are currently being used to determine boundary layer parametizations (see Summary No. 5.6).

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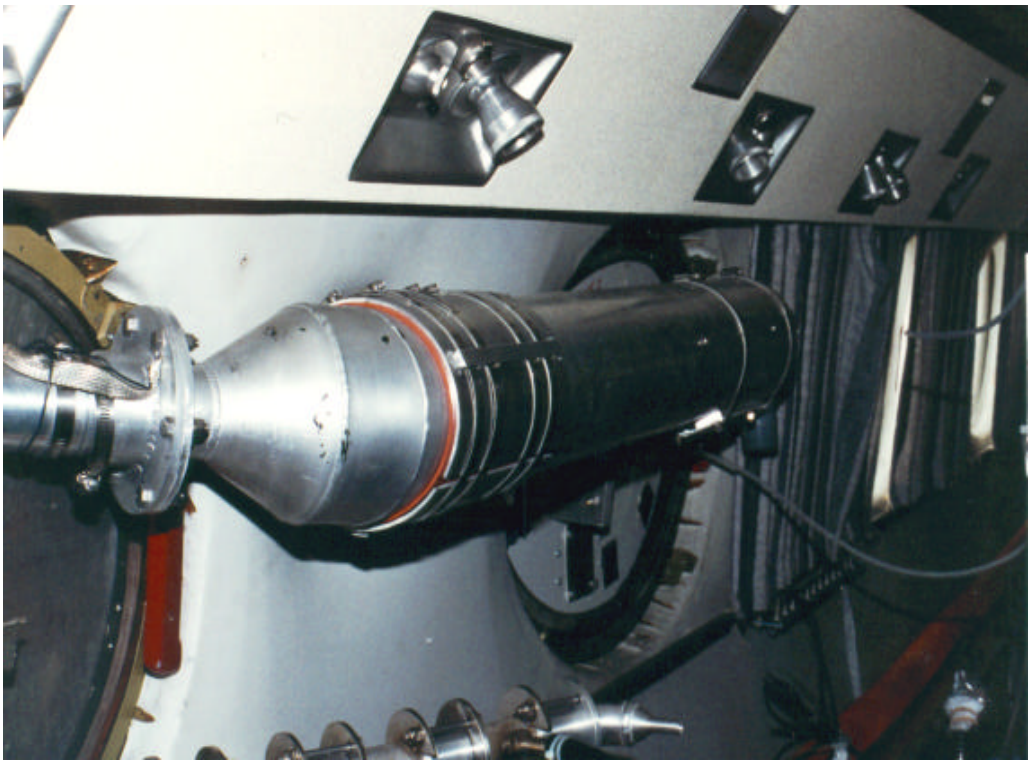

Figure 5.4 The Radgrabber installed on the G-1.

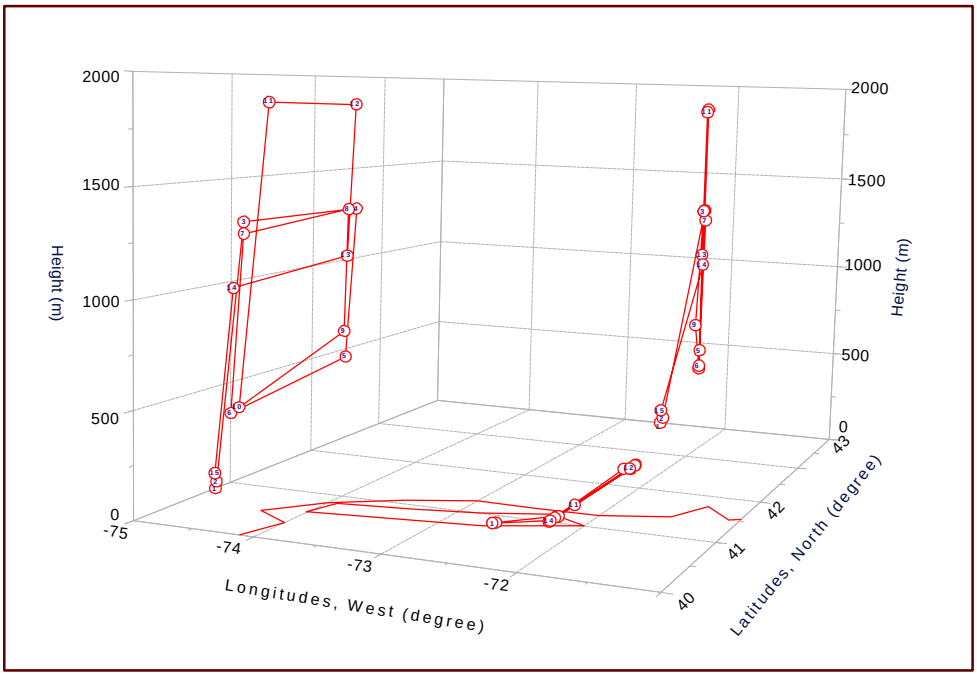

Figure 5.5 The flight path during the September 3rd, 1995 mission.

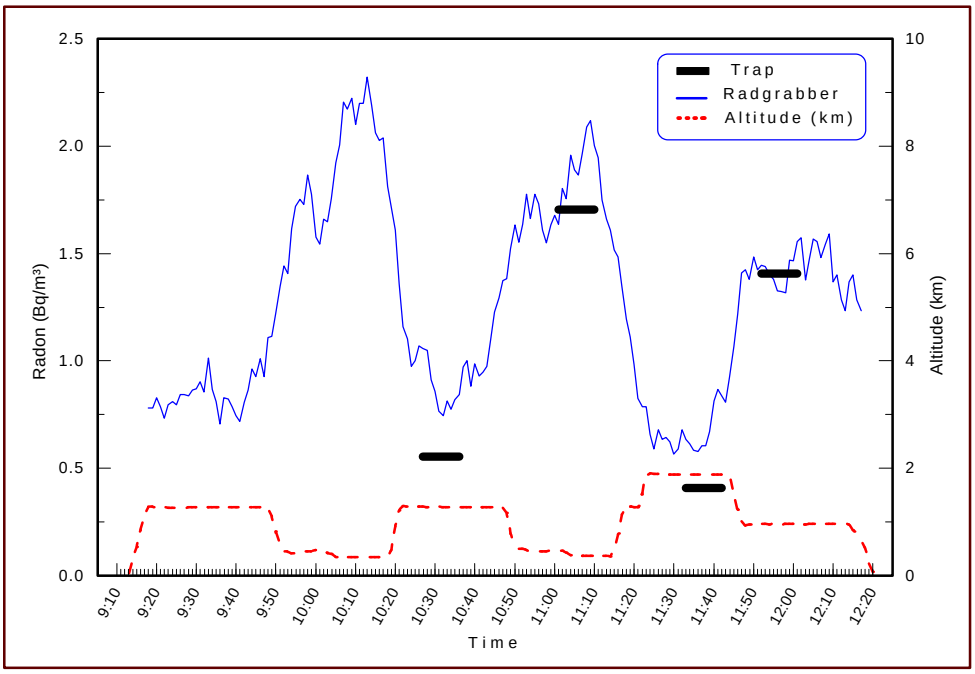

Figure 5.6 Time dependent ^{222}Rn concentrations (Bq/m^3) obtained from the Radgrabber and from trap sam
the G-1.

5.5 CONTINUED TESTING AND EVALUATION OF THE RADGRABBER

Vincent C. Negro, Norman Y. Chiu, Richard J. Larsen, Scott B. Wurms and Cecilia Breheny

The continued testing and evaluation of the "Radgrabber" is required to fully maximize the operational performance of this newly designed instrument (See Summary No. 5.4). Unfortunately, it is difficult to test and evaluate the instrument in the laboratory or inside a test chamber. The ^{222}Rn progeny interact with the many available surfaces, altering the ^{222}Rn/^{218}Po/charged ^{218}Po relationships. We, therefore, must restrict our testing of the instrument to areas removed from local surfaces. During aircraft flights, the instrument samples air in the free atmosphere, away from local surfaces, but flight time is limited and expensive. An alternate testing platform was set up in the fall of 1995 (Figure 5.7). The Radgrabber was mounted to a 40 ft (~13 m) adjustable ladder which was mounted to the rear of EML's field van. The Radgrabber was hoisted to a height of 37 ft. (~12.3 m) above the ground and was oriented into the wind. In addition to the Radgrabber, a Davis Weather Monitor II wind vane and temperature/dewpoint probe and a sampling inlet for an EML ^{222}Rn gas analyzer, which was located inside the van, were also secured to the top of the ladder. Using this setup, we are able to operate the Radgrabber away from local surfaces and continuously measure the ^{222}Rn concentration and meteorological parameters of the air mass being sampled. The data obtained from the initial testing of this configuration at an open field in Floyd Bennet Field, New York City, is encouraging and continued tests will be conducted during 1996.

Figure 5.7 Test and evaluation platform for the Radgrabber.

5.6 AN ADVANCED NUMERICAL MODEL FOR CALCULATING VERTICAL PROFILES OF ^{222}Rn AND VERTICAL DIFFUSIVITY IN THE ATMOSPHERIC BOUNDARY LAYER

Hsi-Na Lee

The ability to accurately calculate the vertical profiles of ^{222}Rn and its daughters is very useful for studying the mechanisms of atmospheric transport and for estimating the variations in the background levels of these airborne radionuclides. A time dependent diffusion equation had generally been used to predict the profiles of ^{222}Rn and its daughters at the measurement sites under specified atmospheric conditions. Horizontal advection was neglected under the assumption that the exhalation rates of ^{222}Rn were uniform over large areas. Thus, the vertical profiles of these radionuclides were strongly related to the ^{222}Rn exhalation and atmospheric turbulence which played an important role for vertical diffusion. The vertical diffusion coefficient is quite variable and changes with height, wind shear and atmospheric stability. In order to accurately calculate the vertical profiles of ^{222}Rn and its daughters, the vertical profile of the diffusion coefficient should be precisely determined and the numerical method for solving the time dependent diffusion equation should minimize the numerical errors. To accurately simulate the vertical profiles of ^{222}Rn, an advanced numerical model using the highly accurate spectral numerical technique was developed. Vertical profiles of ^{222}Rn in the atmospheric boundary layer were calculated for several typical profiles of the turbulent diffusion coefficient. The best profile of vertical diffusivity is chosen from the profiles of the diffusion coefficients that produced the best agreement between the calculated profiles of ^{222}Rn and the measured profiles. This modeling technique is being used to study boundary layer parametization using the vertical profiles of ^{222}Rn obtained during the 1995 Northeast Field Study (see Summary No. 5.4).

5.7 MODELING TRANS-PACIFIC TRANSPORT OF COMBUSTION PRODUCTS FROM ASIA BY USING A GLOBAL CHEMISTRY MODEL

Hsi-Na Lee

The long-range transport of Asian combustion products across the Pacific Ocean is of current interest to the scientific community. Asian fossil-fuel consumption and emissions are expected to continue to grow rapidly in the future. These products, when emitted into the atmosphere and transported globally, could have a significant effect on the global climate. By modeling the transport of these pollutants, the current and future trends and the potential impact of these pollutants on the United States can be estimated. A three-dimensional Global Chemistry Model (GChM) which was derived from the original code, PLUVIUS, developed by Dr. Jeremy Hales, ENVAIR, Kennewick, WA, was chosen in order to quantify this impact and to understand the transport processes. The model applies a Eulerian frame and is capable of simulating complex chemistries and other source-receptor behaviors for any specified number of pollutants. In 1995, a joint modeling effort was established between Dr. Lee and Dr. Hales to examine the model's performance for simulating ^{222}Rn transport from Asia across the Pacific Ocean. The transport of ^{222}Rn from Asia should closely mirror

the transport of Asian combustion products. Figure 5.8 presents the results of one of the simulations, showing the transport of radon crossing over to the Pacific Ocean and reaching as far as the West Coast of the United States. The collaboration between Dr. Lee and Dr. Hales is expected to continue in the future.

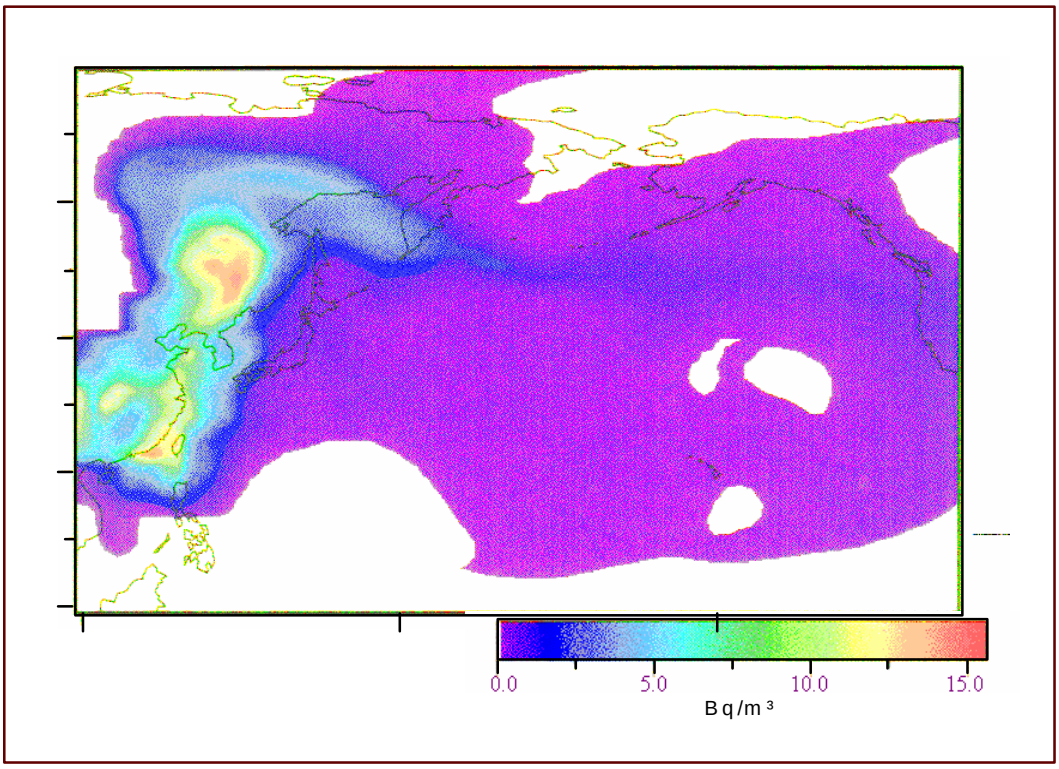

Figure 5.8 A simulated distribution of ^{222}Rn emitted from China after 30-days.

5.8 RADON SOURCE TERMS TO THE ATMOSPHERE

Adam R. Hutter

Atmospheric ^{222}Rn data is used by modelers to evaluate and validate the transport component of General Circulation Models (GCM). Currently, a value of 1 ^{222}Rn atom cm^{-2} sec^{-1} flux rate is used as the source term to the atmosphere for every global land mass. There is a need for better defined and more realistic emission rates of ^{222}Rn, reflecting global differences in, among other parameters, climate and rock and soil type. Working with researchers at the New Mexico Institute of Mining and Technology, modeling ^{222}Rn flux from databases of soil texture, surficial geology and soil moisture was considered to be the only viable approach to solving this problem.

One aspect of developing realistic global estimates of ^{222}Rn emission to the atmosphere involves understanding seasonal variations in ^{222}Rn flux, such that a set of global ^{222}Rn emission rate databases may be needed in order to take into account the effects of global differences in temperature, precipitation and other climate related parameters on the ^{222}Rn flux. Towards this end, a sampling project in a homogeneous setting (New Jersey coastal plain province sands and gravels) was initiated to study seasonal changes in the ^{222}Rn flux to the atmosphere. These findings were presented at the 1995 Spring Meeting of the American Geophysical Union held in Baltimore, MD (Hutter, 1995). Figure 5.9 shows the results of the ^{222}Rn flux measurements and a model based on a data fit following a Fourier analysis. This figure shows the ^{222}Rn flux to be about three times higher in the summer than during the winter at this site, a phenomenon that has not been incorporated into any current ^{222}Rn flux estimates.

During the planning of the project, it was decided that any ^{222}Rn flux maps produced need to be "calibrated" from existing data of ^{222}Rn flux. However, since there are only a few published results of direct measurements of ^{222}Rn flux, another aspect that needed to be addressed concerned the overall reproducibility of direct ^{222}Rn flux measurements. Towards this end, a rigorous assessment of the reproducibility of ^{222}Rn flux measurements using the "accumulation can" technique was investigated through field studies. These results were presented at the American Geophysical Union's 1994 Fall Meeting in San Francisco, CA. In summary, the percentage error in the ^{222}Rn flux measurements determined from the ratio of the arithmetic mean of the standard deviation to the arithmetic mean of the ^{222}Rn flux for each set of measurements was ~25%. Approximately half of this value is attributed to the error in the ^{222}Rn measurement, estimated to be 10-12% at the low concentrations measured. This question was also addressed at the Sixth International Radon Metrology Program Intercomparison Test and Workshop organized and held at EML from April 28 to May 10, 1995 (see Summary No. 3.4).

During this exercise, researchers from around the world intercompared their measurements of ^{222}Rn flux from a standard concrete slab, as well as in the field. The results showed that the researchers agreed to within ~ 25% of each other in the field and to within ~ 15% of each other in the laboratory-based standard slab measurements (Hutter and Knutson, 1996). These results provide a basis from which to evaluate the feasibility of collectively using ^{222}Rn flux data collected by many different researchers using a variety of techniques in calibrating any global ^{222}Rn emission rate database.

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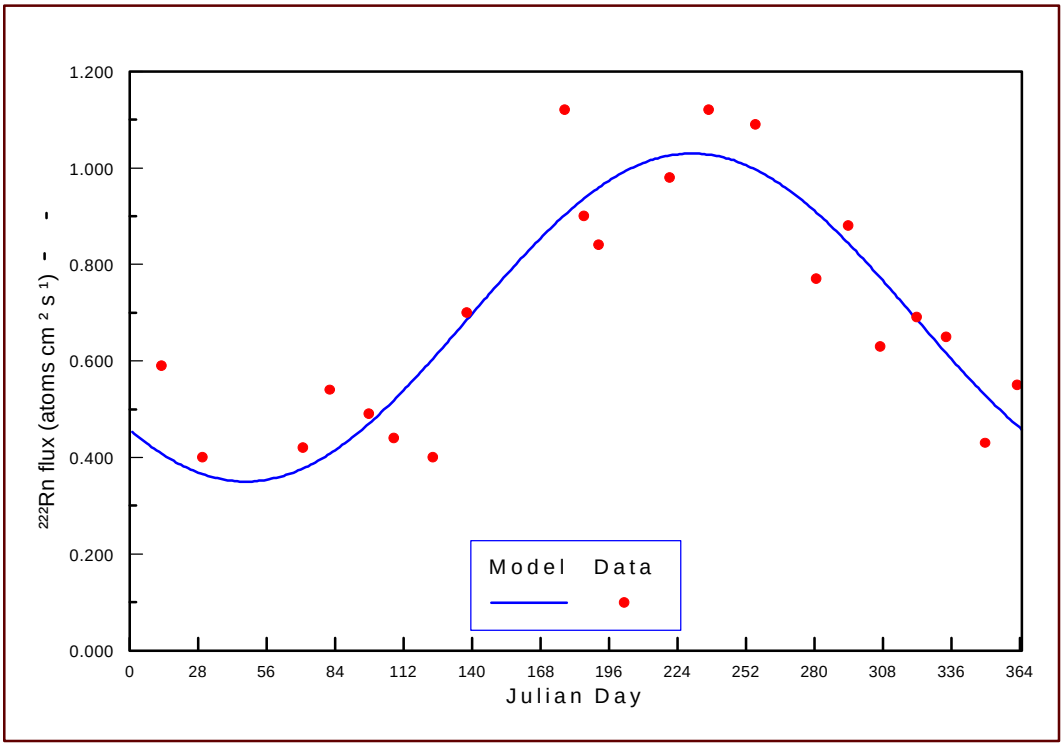

Figure 5.9 Results of ^{222}Rn flux data and a model based on a data fit following a Fourier analysis. Each data point represents the arithmetic mean of 16 individual measurements. Uncertainties associated with the data points are calculated from the standard deviation/the arithmetic mean for each data point, the arithmetic mean for all the points being ~ 20%. The correlation coefficient (r) between the data and the model is 0.90.